PID IMPLEMENTATION OF UMP MINI AUTOMATION PLANT
PART 1 - HEATING TANK

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ABSTRACT

A temperature control unit is a special I/O units that receive inputs directly from thermocouple, perform PID control with 2 degree of freedom and output results through open collector outputs. Temperature control is very difficult to be implemented by using ordinary control techniques, hence the purpose of this research is to describe the implementation of PID controller design based on programmable logic controller (PLC) in order to control the time to heat up a particular solution to a desired temperature. The PLC OMRON CJIM-CPU12 and the temperature control unit CJ1W-TC001 is 2 vital parts in this research. UMP mini automation plant involved in this project is initially malfunction, so reverting it back to its original functional state is set to main priority and followed by detail PID analysis of heating tank (tank 2) of UMP mini automation plant.

ABSTRAK

Unit pengawal suhu ialah I/O unit khas yang menerima input secara langsung daripada thermocouple, melaksanakan PID *control* dengan *2 degree of freedom*, dan keputusan dihantar melalui *open collector outputs*. Pengawalan suhu adalah sangat susah untuk dilaksanakan dengan pengawalan biasa, tujuan penyelidikan ialah untuk menghuraikan implimentasi PID *controller* berdasarkan *programmable logic controller* (PLC) untuk mengawal masa yang diperlukan untuk memanaskan sesuatu larutan ke suhu yang dikehendaki. PLC OMRON CJIM-CPU12 dan Unit pengawal suhu CJ1W-TC001 ialah 2 bahagian yang paling penting dalam penyelidikan ini. Disebebkan *UMP mini automation plant* adalah dalam keadaan tidak berfungsi, tumpuan utama telah disetkan untuk membaiki mini plant dan seterusnya PID analisis dibuat terhadap *heating tank (tank 2) UMP mini automation plant.*

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LIST OF ABBREVIATIONS

PLC	Programmable Logic Controller
P	Proportional Controller
PI	Proportional-Integral Controller
PID	Proportional-Integral-Derivative Controller
SP	Set Point
MV	Manipulated Variable
PV	Process Variable
TCU	Temperature Control Unit
CPU	Central Processing Unit (Computer)

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter explains the overview of this project, giving readers a general idea of what this project concept are about. Chapter starts with explanation of PID concept, followed by component introduction where PID are implemented. Problem statement, objective and project scopes are clarified next, subsequently some examples are given as application of project.

1.1 Concept Background

The proportional-integral-derivative (PID) controllers are broadly used in many industrial control systems for several decades since Ziegler and Nichols proposed the first PID tuning method. This is because the PID controller structure is simple and its principle is easier to understand than most other advanced controllers [1].

On the other hand, the general performance of PID controller is satisfactory in many applications. For these reasons, the majority of the controllers used in industry are of PI/PID type. PID controllers are widely used for process control applications requiring very precise and accurate control. Unlike on/off controls, the smooth and steady state control is achievable using these controllers. Various models are available featuring single loop with universal input, two to eight loops with eight independent inputs and sixteen control outputs.

1.1.1 Project Introduction

The purpose of a temperature controller unit is to heat up a particular solution to a desire temperature with the minimum overshoot and quickest time constant, in other word the optimum result. Heater comes in a variety of size and power consumption, basically the higher the power consumption the faster the heating process will be. The system operates in a closed loop system to ensure the desired temperature will be obtained in fastest time and accurately.

PID Controller in this study requires the knowledge of tuning the constants to find the best value. The theory show that the control with Proportional-Integral-Derivative Controller (PID) can improve in terms of percentage overshoot and time constant.

This project development include implementing PID controller with Programmable Logic Controller (PLC) ladder diagram programming to control the heater. UMP mini automation plant involved in this project is initially malfunction, so reverting it back to its original functional state is set to main priority in this project and followed by detail PID analysis of heating tank (tank 2) of UMP mini automation plant.

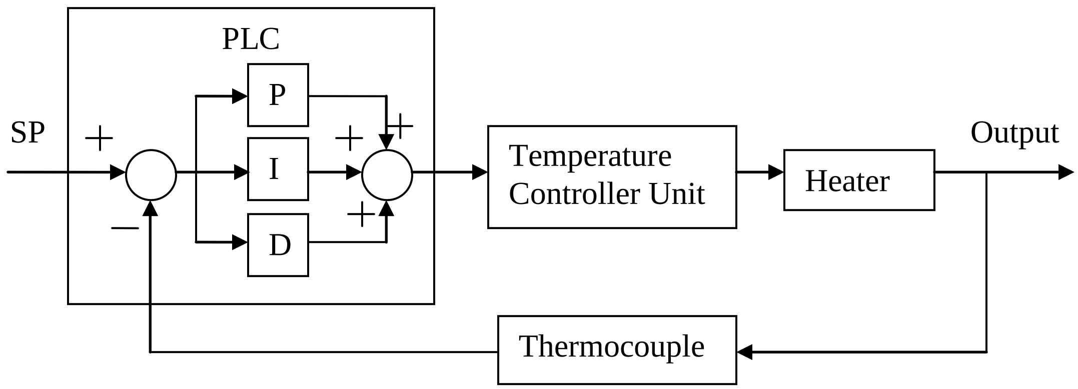

Figure 1.1: Project overview

Figure 1.1 is the block diagram of this project, showing how PLC, PID, TCU, heater and sensor are related to each other to form a closed loop system. Further explanation regarding PID controller and tuning is available in chapter 2 along with detail information about PLC and TCU used.

1.1.1 Problem Statements

Plant mechanism are easily damage without implementation of any controller methodology in the system so a closed loop system is used to overcome this. Besides, human supervisory is also ineffective to be applied in gigantic industries. Thus, control system is applied to the industries to replace the supervisory position's responsibility.

Furthermore a closed loop system able to predict and make correction to current process so that output will remain in a range and not differ too much. Comparing to manual operation or an open loop system, closed loop system is far more superior due to its ability to detect, predict and give feedback to the system when needed. Closed loop system able to improve few things that are always concerned in these kind of process time constant and overshoot for example.

In industries workers often need work under hazard condition, by implementing PLC this problem can be solved partially. Because not only it act as a monitor but a controller, as it able to connect to all kinds of hardware. Recent technology improved to a new level of wireless connection using Bluetooth device or wireless wavelength, enabling user to monitor and control PLC at PC distance away from PLC.

1.2 Objectives

The objectives of this project is to ensure the mini plant able to run again at the end of this project and to implement PID at the heating tank, analyze and obtain the best tuning constant to allow the mini plant work in the optimum condition. Finally to add few new features to existing PLC and touch screen program.

1.3 Project Scopes

This research is to implement PID controller in heating tank, ladder diagram will be modify to improve process and allow more option to make simulation easier. Simulation will be made by using different PID constant and the analysis will show the efficiency and performance of different tuning constant at system:-

i. Maintenance and repairing mini plant.
ii. Studies of Touch screen programming consist of Project Manager.
iii. Studies of PLC Programming consist of CX-Programmer (V 6.1)
iv. Design to improve PLC ladder diagram programming and PID Controller implementation at the heating tank.

1.4 Project Applications

UMP mini plant is designed based on automated drink manufacturing plant, the stations and components it installed with is almost identical with the actual ones from food processing industry starting from bottle supply station to rejecting station and packaging station.

As mentioned above, UMP mini plant is not only a dummy but actually a functional system, it is very suitable to act as teaching material and exclusively great introduction to student that lack of real life interaction with hardware, machinery and their applications.

1.5 Thesis Outline

Chapter 1 Introduction, put main concept and project overview into the picture. Followed by clarifying problem statement, objective and project scope to make sure works done are always right on track. Lastly, some project application that able to make use of this project was suggested.

Chapter 2 is about Literature Review, which it goes into detail on PLC, TCU, touch screen, PID controller and each of its component. Related books, journals and articles are used as references as guide to aid finishing this project.

Chapter 3 Methodology, describe the process to accomplish this project in flow chat and explanation are available for each phase, also related software used are introduced here generally on what it capable to do.

Chapter 4 is Result and Discussion, of which all work done are presented in words, tables, and graphs, finally best tuning constant are clarified and statement according to graph and discussion are made.. In addition, limitation to this project is stated here, this part is also important as a reminder and guide for future references.

Chapter 5 is Conclusion and Recommendation which conclude the development of project. Recommendation is included to encourage more improvement made to UMP mini plant.

CHAPTER 2

LITERATURE REVIEWS

This chapter is the summary of all related study material and components required in this research. All ideas and concepts yield are to be implemented on the research. This Chapter reviews PID controller, PLC, Temperature Control Unit and Touch Screen.

2.1 PID Controller

Conventional proportional-integral-derivative (PID) controller are widely used in industry process control ,due to its simplicity in structure and ease of implementation [1]. Although the control theory and method has got great progress, PID controllers are still common and well known.

Statistic of metallurgical industry, chemical industry and food industry etc. show that 97% of the controllers select PID structure [2]. An important objective of control system design is to minimize the effects of external disturbances. The problem if disturbance rejection arises in many industrial fields, such as motion-control, active noise control and vibration control [8].

Generally a PID controller is a control loop feedback mechanism widely used in industrial control system sector. In practice the dynamics of the rise and decay of the plant output parameter $Y_a(t)$ can be different. The plants with this feature are called Plants with the asymmetric dynamics [3] or asymmetrical processes [4,5]. Often they are found in water supply and heating control systems. The parameters of such a plant transfer function or even the transfer function itself changes when the sign of the Y(t) time derivative d Y(t)/dt changes. In fact such kinds of plants are plants with switched parameters do not allow us to achieve good behavior of the control systems [3].

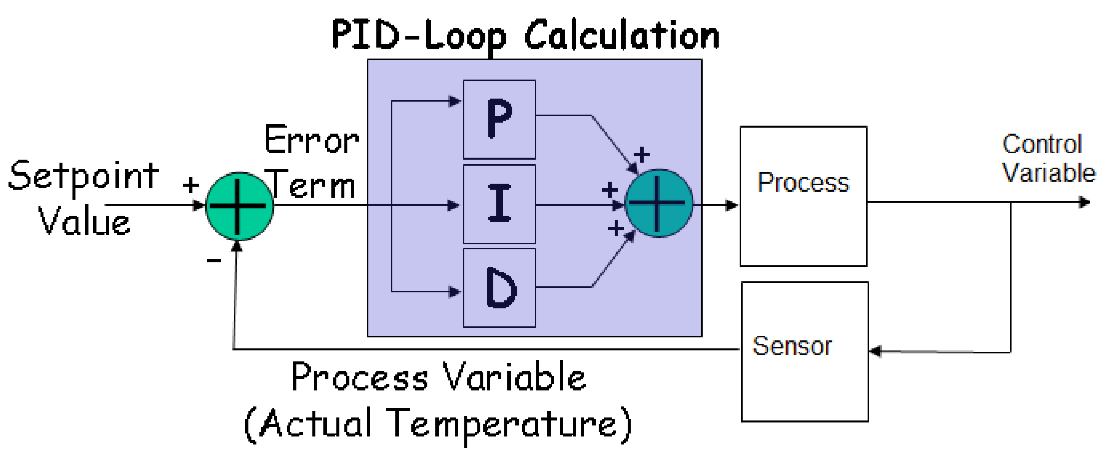

Figure 2.1: PID loop

PID measure the differences between the desire value and the actual value, by using the error calculated, it attempt to minimize it by adjusting the control input to obtain the desire output value. By tuning the 3 parameters in PID, the controller can provide specific control action designed for different requirements. In the field of metallurgy, chemistry, food industry and oil refining due to the time delay and process parameter uncertainty, the parameter of PID controller need automatic adjustment [6].

2.1.1 Proportional Control

The proportional value determines the reaction to the current error, the proportionality constant (KP) is known as the proportional gain of the controller. to get a higher performance output, the gain must be increase but it is well known that the controller with too large gain should be avoided because it will cause instability [7]; while a low proportional gain will result small output response and a less sensitive controller.

2.1.2 Integral Control

The integral value determines the reaction based on the sum of recent errors, by adding instantaneous error over time gives the accumulated offset that should have been corrected previously [8,9]. The integral gain eliminates the residual steady-state error that occurs with a proportional only controller, however it can cause the present value to overshoot the set point value, since the integral term is responding to accumulated errors from the past.

2.1.3 Derivative Control

The derivative value determines the reaction based on the rate at which the error has been changing. Adding a derivative term can improve the stability, reduce the overshoot that rises when proportional or high gain integral terms are used, and improve response speed by predicting changes in the error [10]. However, differentiation of a signal amplifies noise and thus this term in the controller is highly sensitive to noise in the error term.

3 most common used controller were the P controller, PI controller and PID controller. A P controller able to reduce the rise time, but never eliminate the steady state error. A PI controller will eliminate the steady state error, but it also may make the transient response worse. A PID controller will increase the system stability, reduce the overshoot, and improve the transient response.